**2015/1** **Algorithm of price adjustment for market equilibrium**
Yurii NESTEROV and Vladimir SHIKHMAN

In this paper, we suggest an algorithm for price adjustment towards a partial market equilibrium. Its convergence properties are crucially based on Convex Analysis. Our price adjustment corresponds to a subgradient scheme for minimizing a special nonsmooth convex function. This function is the total excessive revenue of the market's participants [16, 18], and its minimizers are equilibrium prices. As the main result, the algorithm of price adjustment is shown to converge to equilibrium prices. Additionally, a market equilibrium clears on average during the price adjustment process. This means that the market clears by historical averages of supply and demand. Moreover, an efficient rate of convergence is obtained. Additionally, we endow our algorithm with decentralized prices by introducing the trade design. The latter suggests that producers settle and update their individual prices, and consumers buy at the lowest purchase price. The proposed price adjustment enjoys a natural behavioral interpretation. First, producers forecast their individual prices to be proportional to their excess demands. For the price update, they subsequently apply an average of these price forecasts over time.

**Keywords:** price adjustment, nonsmooth convex optimization, subgradient methods, decentralization of prices, partial equilibrium, historical averaging.

**2015/2** **Oligopolistic vs. Monopolistic Competition: Do Intersectoral Effects Matter?**
Claude D'ASPREMONT and Rodolphe DOS SANTOS FERREIRA

Recent extensions of the standard Dixit-Stiglitz (1977) model, that go beyond the CES sub-utility assumption, while maintaining monopolistic competition, have mainly emphasized the role of intrasectoral substitutability. We argue that introducing oligopolistic competition can be an alternative extension, still tractable, allowing to restore the role of intersectoral substitutability and reinforcing the general equilibrium dimension of the model. For this purpose, we use the concept of oligopolistic equilibrium and derive a comprehensive formula to characterize the set of potential equilibria with varying competitive toughness. For two particular competitive regimes, price competition and quantity competition, we show how, with strategic interactions, pro-competitive or anti-competitive effects now depend on the elasticity of intersectoral substitution as compared to the elasticity of intrasectoral substitution.

**Keywords:** monopolistic competition, oligopolistic competition, general equilibrium, intersectoral substitution.
**JEL Classification**: D43, D51, L13.

**2015/3** **Complexity bounds for primal-dual methods minimizing the model of objective function**
Yurii NESTEROV

We provide Frank-Wolfe (≡ Conditional Gradients) method with a convergence analysis allowing to approach a primal-dual solution of convex optimization problem with composite objective function. Additional properties of complementary part of the objective (strong convexity) significantly accelerate the scheme. We also justify a new variant of this method, which can be seen as a trust-region scheme applying the linear model of objective function. Our analysis works also for a quadratic model, allowing to justify the global rate of convergence for a new second- order method. To the best of our knowledge, this is the first trust-region scheme supported by the worst-case complexity bound.

**Keywords:** convex optimization, complexity bounds, linear optimization oracle, conditional gradient method, trust-region method.

**2015/4** **Strongly polynomial bounds for multiobjective and paprametric globam minimum cost in graphs and hypergraphs**
Hassène AISSI, A. Ridha MAJHOUB, S. Thomas MCCORMICK, and Maurice QUEYRANNE

We consider multiobjective and parametric versions of the global minimum cut problem in undirected graphs and bounded-rank hypergraphs with multiple edge cost functions. For a fixed number of edge cost functions, we show that the total number of supported non-dominated (SND) cuts is bounded by a polynomial in the numbers of nodes and edges, i.e., is strongly polynomial. This bound also applies to the combinatorial facet complexity of the problem, i.e., the maximum number of facets (linear pieces) of the parametric curve for the parametrized (linear combination) objective, over the set of all parameter vectors such that the parametrized edge costs are nonnegative and the parametrized cut costs are positive. We sharpen this bound in the case of two objectives (the bicriteria problem), for

which we also derive a strongly polynomial upper bound on the total number of non-dominated (Pareto efficient) cuts. In particular, the bicriteria global minimum cut problem in an n-node graph admits $O(n3 \log n)$ SND cuts and $O(n5 \log n)$ non- dominated (Pareto efficient) cuts. These results significantly improve on earlier graph cut results by Mulmuley (1999) and Armon and Zwick (2006). They also imply that the parametric curve and all SND cuts, and, for the bicriteria problems, all Pareto efficient cuts, can be computed in strongly polynomial time when the number of objectives is fixed.

**2015/5** **Optimal Taxation Theory and Principles of Fairness**
Marc FLEURBAEY and François MANIQUET

The achievements and limitations of the classical theory of optimal labor-income taxation based on social welfare functions are now well known, although utilitarianism still dominates public economics. We review the recent interest that has arisen for broadening the normative approach and making room for fairness principles such as desert or responsibility. Fairness principles sometimes provide immediate recommendations about the relative weights to assign to various income ranges, but in general require a careful choice of utility representations embodying the relevant interpersonal comparisons. The main message of this paper is that the traditional tool of welfare economics, the social welfare function framework, is flexible enough to incorporate many approaches, from egalitarianism to libertarianism.

**Keywords:** optimal taxation, fair social orderings.
**JEL Classification:** H21, D63.

**2015/6** **Heuristics for exact nonnegative matrix factorization**
Arnaud VANDAELE, Nicolas GILLIS, François GLINEUR, and Daniel TUYTTENS

The exact nonnegative matrix factorization (exact NMF) problem is the following: given an m-by-n nonnegative matrix X and a factorization rank r, find, if possible, an m-by-r nonnegative matrix W and an r-by-n nonnegative matrix H such that X = WH. In this paper, we propose two heuristics for exact NMF, one inspired from simulated annealing and the other from the greedy randomized adaptive search procedure. We show that these two heuristics are able to compute exact nonnegative factorizations for several classes of nonnegative matrices (namely, linear Euclidean distance matrices, slack matrices, unique-disjointness matrices, and randomly generated matrices) and as such demonstrate their superiority over standard multi-start strategies. We also consider a hybridization between these two heuristics that allows us to combine the advantages of both methods. Finally, we discuss the use of these heuristics to gain insight on the behavior of the nonnegative rank, i.e., the minimum factorization rank such that an exact NMF exists. In particular, we disprove a conjecture on the nonnegative rank of a Kronecker product, propose a new upper bound on the extension complexity of generic n-gons and conjecture the exact value of (i) the extension complexity of regular n-gons and (ii) the nonnegative rank of a submatrix of the slack matrix of the correlation polytope.

**Keywords**: extension complexity, slack matrices, linear Euclidean distance matrices, nonnegative rank, hybridization, simulated annealing, heuristics, exact nonnegative matrix factorization, nonnegative matrix factorization.

**2015/7** **Autoregressive moving average infinite hidden Markov-switching models**
Luc BAUWENS, Jean-François CARPENTIER, and Arnaud DUFAYS

Markov-switching models are usually specified under the assumption that all the parameters change when a regime switch occurs. Relaxing this hypothesis and be- ing able to detect which parameters evolve over time is relevant for interpreting the changes in the dynamics of the series, for specifying models parsimoniously, and may be helpful in forecasting. We propose the class of sticky infinite hidden Markov- switching autoregressive moving average models, in which we disentangle the break dynamics of the mean and the variance parameters. In this class, the number of regimes is possibly infinite and is determined when estimating the model, thus avoid- ing the need to set this number by a model choice criterion. We develop a new Markov chain Monte Carlo estimation method that solves the path dependence issue due to the moving average component. Empirical results on macroeconomic series illustrate that the proposed class of models dominates the model with fixed parameters in terms of point and density forecasts.

**Keywords:** ARMA, Bayesian inference, Dirichlet process, Forecasting, Markov-switching.
**JEL Classification:** C11, C15, C22, C53, C58.

**2015/8** **Multidimensional Poverty Measurement with Individual Preferences**
Koen DECANCQ, Marc FLEURBAEY, and François MANIQUET

We propose a new class of multidimensional poverty indices. To aggregate and weight the different dimensions of poverty, we rely on the preferences of the concerned agents rather than on an arbitrary weighting scheme selected by the analyst. The Pareto principle is, therefore, satisfied among the poor. The indices add up individual measures of poverty that are computed as a convex transform of the fraction of the poverty line vector to which the agent is indifferent. The axiomatic characterization of this class is grounded on new principles of interpersonal poverty comparisons and of inequality aversion among the poor. We illustrate our approach with Russian survey data between 1995 and 2005. We find that, compared to standard poverty indices, our preference sensitive indices lead to considerable differences in the identification of the poor and in subgroup poverty comparisons.

**Keywords:** multidimensional poverty measurement, preferences.
**JEL Classification:** D63, D71.

**2015/9** **Largest minimal inversion-complete and pair-complete sets of permutations**
Eric BALANDRAUD, Maurice QUEYRANNE, and Fabio TARDELLA

We solve two related extremal problems in the theory of permutations. A set $Q$ of permutations of the integers 1 to $n$ is inversion-complete (resp., pair-complete) if for every inversion $(i, i)$, where $1 \le i < j \le n$, (resp., for every pair $(i, j)$, where $i \neq j$) there exists a permutation in $Q$ where $j$ is before $i$. It is minimally inversion-complete if in addition no proper subset of $Q$ is inversion-complete; and similarly for pair-completeness. The problems we consider are to determine the maximum cardinality of a minimal inversion-complete set of permutations, and that of a minimal pair-complete set of permutations. The latter problem arises in the determination of the Carathéodory numbers for certain abstract convexity structures on the $(n \quad 1)$-dimensional real and integer vector spaces. Using Mantel's Theorem on the maximum number of edges in a triangle-free graph, we determine these two maximum cardinalities and we present a complete description of the optimal sets of permutations for each problem. Perhaps surprisingly (since there are twice as many pairs to cover as inversions), these two maximum cardinalities coincide whenever $n \ge 4$.

**2015/10** **Carathéodory, helly and radon numbers for sublattice convexities**
Maurice QUEYRANNE and Fabio TARDELLA

The Carathéodory, Helly, and Radon numbers are three main invariants in convexity theory. They relate, respectively, to minimal representations of points in a convex hull; to the size of minimal infeasible inequality systems; and to VC-dimensions and the existence of centerpoints (generalized medians). These invariants have been determined, exactly or approximately, for a number of different convexity structures. We consider convexity structures defined by the sublattices and by the convex sublattices of finite-dimensional Euclidian, integer and Boolean spaces. Such sublattices arise as feasible sets in submodular optimization (lattice programming) and in monotone comparative statics of optimization and fixed-point problems. We present new results on the exact Carathéodory numbers for these sublattice convexities. Our results imply, for example, that if a subset $S$ of a finite set $D$ can be obtained with unions and intersections from a given family $G$ of subsets of $D$, then $S$ can be obtained with unions and intersections from a small subfamily of $G$. Convex sublattice and integral L-natural convexities are induced by polyhedra defined by dual generalized network flow constraint systems. We reduce the problem of finding the Carathéodory number for the integral L-natural convexity to an extremal problem in the theory of permutations, namely, finding the maximum size of a minimal cover of all ordered pairs of elements from a finite set using permutations of that set; this extremal problem is solved in a companion paper co-authored with Eric Balandraud. We also find very close upper and lower bounds for the other Carathéodory numbers, and the exact Helly and Radon numbers of most of these convexities. We leave as open problems the determination of the Helly and Radon numbers of the integer convex sublattice convexity.

**2015/11** **Does Techological Progress Affect the Location of Economic Activity?**
Takatoshi TABUCHI, Jacque-François THISSE, and Xiwei ZHU

We show that how technological innovations and migration costs interact to shape the space-economy. Regardless of the level of transport costs, rising labor productivity fosters the agglomeration of activities, whereas falling transport costs do not affect the location of activities. When labor is heterogeneous, the number of workers residing in the more productive region increases by decreasing order of productive efficiency when labor productivity rises. This process affects in opposite directions the welfare of those who have a lower productivity.

**2015/12** **Toward a Theory of Monopolistic Competition**
Mathieu PARENTI, Philip USHCHEV, and Jacque-François THISSE

We propose a general model of monopolistic competition with unspecified preferences. Our analysis applies to the case of symmetric/asymmetric preferences and costs. Our basic tool is the elasticity of substitution function, which is shown to depend on the actions taken by firms. We impose intuitive conditions on this function to guarantee the existence of a free-entry equilibrium. Comparative statics with respect to population size, GDP per capita and productivity shocks (the pass-through rate) is conducted by means of necessary and sufficient conditions in the case of symmetric firms.

**Keywords:** monopolistic competition, general equilibrium, additive preferences, homothetic preferences.
**JEL Classification:** D43, L11, L13.

**2015/13** **Smooth strongly convex interpolation and exact worst-case performance of first-order methods**
A.B. TAYLOR, J.M. HENDRICKX, François GLINEUR

We show that the exact worst-case performance of fixed-step first-order methods for smooth (possibly strongly) convex functions can be obtained by solving convex programs.
Finding the worst-case performance of a black-box first-order method is formulated as an optimization problem over a set of smooth (strongly) convex functions and initial conditions. We develop closed-form necessary and sufficient conditions for smooth (strongly) convex interpolation, which provide a finite representation for those functions. This allows us to reformulate the worst-case performance estimation problem as an equivalent finite dimension-independent semidefinite optimization problem, whose exact solution can be recovered up to numerical precision. Optimal solutions to this performance estimation problem provide both worst-case performance bounds and explicit functions matching them, as our smooth (strongly) convex interpolation procedure is constructive.
Our works build on those of Drori and Teboulle in [8] who introduced and solved relaxations of the performance estimation problem for smooth convex functions.
We apply our approach to different fixed-step first-order methods with several performance criteria, including objective function accuracy and residual gradient norm. We conjecture several numerically supported worst-case bounds on the performance of the gradient, fast gradient and optimized fixed-step methods, both in the smooth convex and the smooth strongly convex cases, and deduce tight estimates of the optimal step size for the gradient method.

**2015/14** **The « wrong skewness » problem in stochastic frontier models : A new approach**
C.M. HAFNER, H. MANNER, L. SIMAR

Stochastic frontier models are widely used to measure, e.g., technical efficiencies of firms. The classical stochastic frontier model often suffers from the empirical artefact that the residuals of the production function may have a positive skewness, whereas a negative one is expected under the model, which leads to estimated full efficiencies of all firms. We propose a new approach to the problem by generalizing the distribution used for the inefficiency variable. This generalized stochastic frontier model allows the sample data to have the wrong skewness while estimating well-defined and non-degenerate efficiency measures. We discuss the statistical properties of the model and we discuss a test for the symmetry of the error term (no inefficiency). We provide a simulation study to show that our model delivers estimators of efficiency with smaller bias than those of the classical model even if the population skewness has the correct sign. Finally, we apply the model to data of the U.S. textile industry for 1958-2005, and show that for a number of years our model suggests technical efficiencies well below the frontier, while the classical one estimates no inefficiency in those years.

**Keywords:** Stochastic frontier model, production efficiency, skewness, testing symmetry preferences
**JEL Classification:** C13, C18, D24.

**2015/15 The Economics of Crowdfunding Platforms**
P. BELLEFLAMME, N. OMRANI, M. PEITZ

This paper provides a description of the crowdfunding sector, considering investment-based crowdfunding platforms as well as platforms in which funders do not obtain monetary payments. It lays out key features of this quickly developing sector and explores the economic forces at play that can explain the design of these platforms. In particular, it elaborates on cross-group and within-group external effects and asymmetric information on crowdfunding platforms.

**Keywords:** Crowdfunding, Platform markets, Network effects, Asymmetric information, P2P lending.
**JEL Classification:** L13, D62, G24s.

**2015/16 Multiple Causation, Apportionment and the Shapley Value**
S. FEREY, P. DEHEZ

Multiple causation is one of the most intricate issues in contemporary tort law. Sharing a loss suffered by a victim among multiple tortfeasors is indeed difficult and Courts do not always follow clear and consistent principles. Here, we argue that the axiomatic approach provided by the theory of cooperative games can be used to clarify that issue. We have considered the question from a purely game theoretic point of view in Dehez and Ferey (2013). Here we propose to analyze it in a legal perspective. We consider in particular the difficult case of successive causation to which we associate a general class of games called "*sequential liability games*". We show that our model rationalizes the two-step procedure proposed by the Restatement Third of Torts, apportionment by causation and apportionment by responsibility. More precisely, we show that the weighted Shapley value associated to a sequential liability game is the legal counterpart of this two-step procedure.

**2015/17 A MIP framework for non-convex uniform price day-ahead electricity auctions**
Mehdi MADANI, Mathieu VAN VYVE

It is well-known that a market equilibrium with uniform prices often does not exist in non-convex day-ahead electricity auctions. We consider the case of the non-convex, uniform- price Pan-European day-ahead electricity market "PCR" (Price Coupling of Regions), with non-convexities arising from so-called complex and block orders. Extending previous results, we propose a new primal-dual framework for these auctions, which has applications in both economic analysis and algorithm design. The contribution here is threefold. First, from the algorithmic point of view, we give a non-trivial exact (i.e. not approximate) linearization of a non-convex 'minimum income condition' that must hold for complex orders arising from the Spanish market, avoiding the introduction of any auxiliary variables, and allowing us to solve market clearing instances involving most of the bidding products proposed in PCR using off-the-shelf MIP solvers. Second, from the economic analysis point of view, we give the first MILP formulations of optimization problems such as the maximization of the traded volume, or the minimization of opportunity costs of paradoxically rejected block bids. We first show on a toy example that these two objectives are distinct from maximizing welfare. We also recover directly a previously noted property of an alternative market model. Third, we provide numerical experiments on realistic large-scale instances. They illustrate the efficiency of the approach, as well as the economics trade-offs that may occur in practice.

**Keywords**: Day-ahead electricity market auctions, Non-convexities, Mixed Integer Programming, Market Coupling, Equilibrium Prices
**Mathematics Subject Classification (2000)**: 90C11 90-80 90C06.

**2015/18 Efficient Taxation with Differential Risks of Dependence and Mortality**
Y. NISHIMURA, P. PESTIEAU

The purpose of this note is to analyze the optimal tax and transfer policies that should be conducted in a society where individuals differ according to their productivity and their risk of mortality and dependency. We show that according to the most reasonable estimates of correlation among these three characteristics, an optimal policy should consist of a tax on earning and second period consumption and of a subsidy on long term care spending. The sign of the tax on saving is ambiguous but we can expect a positive tax on saving in reasonable cases.

**Keywords:** Long term care, mortality risk, efficient taxation
**JEL Classification:** H2, H5.

**2015/19** **Nature or Nurture in Higher Education? Inter-generational Implications of the Vietnam-Era Lottery**
Louis N. CHRISTOFIDES, Michael HOY, Joniada MILLA, Thanasis STENGOS

It is evident that a strong positive correlation persists between the educational attainment of parents and that of their children in many, if not most, populations. This relationship may form an important part of the phenomenon of low social mobility as well as inefficiently low investment in human capital by youth who have parents with relatively low educational attainment. Is it a genetic inter-generational transmission of innate ability from parents to their children (i.e. nature) or is it the environment that the better educated parents provide for their children (i.e. nurture) that explains this positive relationship? Understanding the relative contributions of nature versus nurture is critical to the development of any social policy designed to increase social and economic mobility between generations. Separating the so-called nature and nurture effects of this relationship is a difficult task. We use the Vietnam Era Draft Lottery as a natural experiment to address the nature-nurture question. Attending university in order to avoid the draft created a cohort which included individuals who would not normally have attended post-secondary educational institutions. Comparing the educational attainment of children of this cohort to that of cohorts who attended university in "normal times" creates a natural experiment to test the relative importance of the nature or nurture explanations. Our findings provide evidence in support of the nurture argument.

**Keywords:** Inter-generational mobility, higher education attendance
**JEL Classification:** IO

**2015/20** **Alternative formulation of the leverage effect in a stochastic volatility model with asymmetric heavy-tailed errors**
Philippe J. DESCHAMPS

This paper investigates three formulations of the leverage effect in a stochastic volatility model with a skewed and heavy-tailed observation distribution. The first formulation is the conventional one, where the observation and evolution errors are correlated. The second is a hierarchical one, where log-volatility depends on the past log-return multiplied by a time-varying latent coefficient. In the third formulation, this coefficient is replaced by a constant. The three models are compared with each other and with a GARCH formulation, using Bayes fac- tors. MCMC estimation relies on a parametric proposal density estimated from the output of a particle smoother. The results, obtained with recent S&P500 and Swiss Market Index data, suggest that the last two leverage formulations strongly dominate the conventional one. The performance of the MCMC method is consistent across models and sample sizes, and its implementation only requires a very modest (and constant) number of filter and smoother particles.

**Keywords:** Stochastic volatility models, Markov chain Monte Carlo, Particle methods, Generalized hyperbolic distribution, Bayesian analysis
**JEL Classification:** C11 ; C15 ; C22 ; C58.

**2015/21** **Equilibrium Leadership in Tax Competition Models with Capital Ownership: A Rejoinder**
J. HINDRIKS, Y. NISHIMURA

This paper reconciles two opposite results in the tax competition literature. On one side Kempf and Rota-Graziosi (J.Pub. Econ 94:768-776, 2010) and Hindriks and Nishimura (J. Pub Econ 121:66-68, 2015) have shown that the two Stackelberg outcomes prevail as the subgame perfect equilibria when capital is entirely owned by non-residents. On the other side Ogawa (Int. Tax Pub Fin 20:474-484, 2013) has shown that the simultaneous-move outcome prevails when capital is entirely owned by residents. We develop a model in which capital ownership can vary freely between these two polar cases. We show that there exists a unique degree of residential capital ownership such that the equilibrium switches from the Stackelberg to the simultaneous-move outcomes. The chance for the simultaneous-move outcome to prevail increases with the extent of asymmetry among regions.

**Keywords:** Endogenous timing ; Tax competition ; Capital ownership
**JEL Classification:** H30, H87, C72.

**2015/22** **The Φ-martingale**
Frédéric VRINS, Monique JEANBLANC

In this paper we focus on continuous martingales evolving in the unit interval [0,1]. We first review

some results about the martingale property of solution to one-dimensional driftless stochastic differential equations. We then provide a simple way to construct and handle such processes. One of these martingales proves to be analytically tractable, and received the specific name of Φ-martingale. It is shown that up to shifting and rescaling constants, it is the only martingale (with the trivial constant, Brownian motion and Geometric Brownian motion) having a separable coefficient $\sigma(t, x) = g(t)h(x)$ that can be obtained via a time-homogeneous mapping of Gaussian processes. The approach is applied to the modeling of stochastic survival probabilities.

**Keywords:** continuous stochastic processes, Gaussian processes, bounded martingales, local martingales, Azéma supermartingale, credit risk modeling
**JEL Classification:** G13, C63.

**2015/23 Attack-Deterring and Damage-Control Investments in Cybersecurity**
W. M. W. Lam

This paper studies investment in cybersecurity, where both the software vendor and the consumers can invest in security. In addition, the vendor can undertake attack-deterring and damage-control investments. I show that full liability, under which the vendor is liable for all damages, does not achieve eciency and, in particular, the vendor underinvests in attack deterrence and overinvests in damage control. Instead, the joint use of an optimal standard, which establishes a minimum compliance framework, and partial liability can restore eciency. This suggests that policies that encourage not only firms, but also consumers to invest in security might be desirable.

**Keywords:** cybersecurity, investment, standard, liability, bilateral care
**JEL Classification:** K13, L1, L8.

**2015/24 Switching Costs in Two-sided Markets**
W. M. W. Lam

In many markets, there are switching costs and network effects. Yet the literature gen- erally deals with these two concepts separately. This paper bridges the gap by analyzing their interaction effects (or “indirect bargain”) in a dynamic two-sided market. I show that in a symmetric equilibrium, the classic result that the first-period price is U-shape in switching costs does not emerge, but instead switching costs always intensify first-period price competition. Moreover, an increase in switching costs on one side decreases the first- period price on the other side. Thus policies that ignore these effects may underestimate the welfare-enhancing effects of switching costs.

**Keywords:** switching costs, two-sided markets, network externality, myopia, loyalty
**JEL Classification:** D43, L13, L96.

**2015/25 The political choice of social long-term care transfers when family gives time and money**

P. De Donder, M-L. Leroux

We develop a model where families consist of one parent and one child, with children differing in income and all agents having the same probability of becoming dependent when old. Young and old individuals vote over the size of a social long-term care transfer program, which children complement with help in time or money to their dependent parent. Dependent parents have an intrinsic preference for help in time by family members. We first show that low (resp., high) income children provide help in time (resp. in money), whose amount is decreasing (resp. increasing) with the child's income. The middle income class may give no family help at all, and its elderly members would be the main beneficiaries of the introduction of social LTC transfers. We then provide several reasons for the stylized fact that there are little social LTC transfers in most countries. First, social transfers are dominated by help in time by the family when the intrinsic preference of dependent parents for the latter is large enough. Second, when the probability of becoming dependent is lower than one third, the children of autonomous parents are numerous enough to oppose democratically the introduction of social LTC transfers. Third, even when none of the first two conditions is satisfied, the majority voting equilibrium may entail no social transfers, especially if the probability of becoming dependent when old is not far above one third. This equilibrium may be local (meaning that it would be defeated by the introduction of a sufficiently large social program). This local majority equilibrium may be empirically relevant whenever new programs have to be introduced at a low scale before being eventually ramped up.

**Keywords:** Majority Voting, local Condorcet winner, crowding out, intrinsic preference for informal help, tax reform
**JEL Classification:** H55, I13, D91.

**2015/26 Long-Term Care and Births Timing**

P. Pestieau, G. Ponthiere

Due to the ageing process, the provision of long-term care (LTC) to the dependent elderly has become a major challenge of our epoch. But our societies are also characterized, since the 1970s, by a postponement of births, which, by raising the intergenerational age gap, can affect the provision of LTC by children. In order to examine the impact of those demographic trends on the optimal policy, we develop a four-period OLG model where individuals, who receive children is informal LTC at the old age, must choose, when being young, how to allocate births along their life cycle. It is shown that, in line with empirical evidence, early children provide more LTC to their elderly parents than late children, because of the lower opportunity cost of providing LTC when being retired. When comparing the laissez-faire with the long-run social optimum, it appears that individuals have, at the laissez-faire, too few early births, and too many late births. We then study, in first-best and second-best settings, how the social optimum can be decentralized by encourageing early births, in such a way as to reduce the social burden of LTC provision.

**Keywords:** Long term care, birth timing, childbearing age, family policy, OLG models
**JEL Classification:** E13, J13, J14.

**2015/27 Longevity Variations and the Welfare State**

P. Pestieau, G. Ponthiere

Life expectancy at birth has more than doubled in Europe since the early 19th century. This demographic trend constitutes a major victory against scarcity, but raises also deep challenges to the Welfare State, concerning the sustainability and the equity of the social security system. This paper surveys recent developments in the economic analysis of longevity, both at the positive and the normative levels. Taking mortality risks into account is shown to affect the study of the lifecycle model significantly, in particular concerning the strength of life horizon effects. It raises also, at the level of normative foundations for policy-making, a dilemma between ex ante and ex post valuations. Finally, we explore the design of policy reforms under varying longevity, in fields

including preventive and curative policies, education, pension, and wealth taxation.

**Keywords:** longevity, mortality risk, inequalities, life cycle, Welfare State
**JEL Classification:** J10, J18, H55.

**2015/28 A Review of Critical Issues on Tax Design and Tax Administration in a Global Economy and Developing Countries**
M. Godin, J. Hindriks

The mobilization of domestic tax resource has become a key issue for developing countries. In this report, we provide some facts and figures on the levels and structures of taxation around the world with special attention to Low Income Countries, (LICs). We use the new ICTD database covering 203 countries with 40 tax items over the period 1980-2010. We discuss some principles of tax design in a global economy that are relevant for LICs. We also review some critical issues on corruption and compliance to see how they relate to growth and tax evasion. We then provide a benchmark framework to assess the overall performance of the government tax collection. We use the tax effort index that measures the gap between the potential tax and the actual tax. The novelty of this tax effort index is twofold. First it takes into account spatial variables to capture the geographic dependence. Second it breaks down the tax effort analysis tax item by tax item to capture the possible tax shift. We conclude with a full ranking of tax effort for all countries and some suggestions of tax reform for a subset of countries that are targeted by the Belgian Development Cooperation.

**Keywords:** Corporate taxation, efficient tax administration, tax enforcement, source-based and destination based taxation, origin and destination principles, Tariffs
**JEL Classification:** C72, H23, H70.

**2015/29 The issue of control in multivariate systems A contribution of structural modelling**
Michel MOUCHART, Guillaume WUNSCH, Frederica RUSSO

This paper builds upon Judea Pearl's directed acyclic graphs approach to causality and the tradition of structural modelling in economics and social science. The paper re-examines the issue of control in complex systems with multiple causes and outcomes, in a specific perspective of structural modelling. It begins with three-variable saturated and unsaturated models, and then examines more complex systems including models with collider and latent confounder discussed by Pearl. In particular, focusing on the causes of an outcome, the paper proposes two simple rules for selecting the variables to be controlled for when studying the direct effect of a cause on an outcome of interest or the total effect when dealing with multiple causal paths. This paper presents a model building strategy that allows a statistical model to be considered as structural. The challenge for the model builder amounts to developing an explanation through a recursive decomposition of the joint distribution of the variables congruent with background knowledge and stable with respect to specified changes of the environment.

**Keywords:** Causality, Control, Structural Modelling, Recursive Decomposition, Total Effect, Direct Effect

**2015/30 Alliance Formation in a Vertically Differentiated Market**
J. J. Gabszewicz, M. A. Marini, O. Tarola

This paper studies how the possibility for firms to sign collusive agreements (as for instance being part of alliances, cartels and mergers) may affect their quality and price choice in a market with vertically differentiated goods. For this purpose we model the firm decisions as a three-stage game in which, at the first stage, firms can form an alliance via a sequential game of coalition formation and, at the second and third stage, they decide simultaneously their product qualities and prices, respectively. In such a setting we study whether there exist circumstances under which either full or partial collusion can be sustained as a subgame perfect Nash equilibrium of the coalition formation game. Also, we analyse the effects of different coalition structures on equilibrium qualities, prices and profits accruing to firms. It is shown that only intermediate coalition structures arise at the equilibrium, with the bottom quality firm always included. Moreover, all equilibrium price and quality configurations always coincide with that observed in the duopoly case, with only two quality variants on sale.

**Keywords:** Vertically differentiated market, endogenous alliance formation, coalition structures, price collusion, grand coalition, coalition stability, sequential games of coalition formation
**JEL Classification:** D42, D43, L1, L12, L13, L41.

**2015/31 Sharing the Proceeds from a Hierarchical Venture**
J. L. Hougaard, J. D. Moreno-Ternero, M. Tvede, L. P. Østerdal

We consider the problem of distributing the proceeds generated from a joint venture in which the participating agents are hierarchically organized. We introduce and characterize a family of allocation rules where revenue 'bubbles up' in the hierarchy. The family is flexible enough to accommodate a no-transfer rule (where no revenue bubbles up) and a full-transfer rule (where all the revenues bubble up to the top of the hierarchy). Intermediate rules within the family are reminiscent of popular incentive mechanisms for social mobilization. Our benchmark model refers to the case of linear hierarchies, but we also extend the analysis to the case in which hierarchies may convey a general tree structure and include joint ownerships.

**Keywords:** Hierarchies, Joint ventures, Resource allocation, Transfer rules, MIT strategy
**JEL Classification:** C71, I10.

**2015/32 Sparse change-point time series models**
Arnaud DUFAYS, Jeroen V. K. ROMBOUTS

Change-point time series specifications constitute flexible models that capture unknown structural changes by allowing for switches in the model parameters. Nevertheless most models suffer from an over-parametrization issue since typically only one latent state vari- able drives the breaks in all parameters. This implies that all parameters have to change when a break happens. We introduce sparse change-point processes, a new approach for detecting which parameters change over time. We propose shrinkage prior distributions allowing to control model parsimony by limiting the number of parameters which evolve from one structural break to another. We also give clear rules with respect to the choice of the hyper parameters of the new prior distributions. Well-known applications are re- visited to emphasize that many popular breaks are, in fact, due to a change in only a subset of the model parameters. It also turns out that sizeable forecasting improvements are made over recent change-point models.

**Keywords:** Time series, Shrinkage prior, Change-point model, Online forecasting
**JEL Classification:** C11, C15, C22, C51.

**2015/33 Status in Organizations**
W. M. W. Lam

Firms can motivate workers by offering them social status (e.g. access to power and privileges) instead of higher pay. Much of the literature emphasizes that status raises work incentives, ignoring the impact of status on coordination. However, I show that when workers need to cooperate with each other and each of them has their own vested interests, too much status differences may exacerbate conflict over workers' preferred actions, and hence distorts coordination. Moreover, it is likely to be profitable for firms to introduce status differential when promotions lead to a change in the roles of the workers.

**Keywords:** status, coordination, promotion, authority, organization
**JEL Classification:** D2, L2, J3.

**2015/34 Competiton in the Market for Flexible Resources: an application to cloud computing**
W. M. W. Lam

This paper considers firms' incentives to invest in local and flexible resources when de- mand is uncertain and correlated. Before demand is realized, two firms invest in their local capacity, and provider(s) of flexible resources invest in their capacity. After demand is realized, firms make their investment decision in flexible resource. I find that market power of the monopolist providing flexible resources distorts investment incentives, while competition mitigates them. The extent of improvement depends critically on demand correlation and the cost of capacity: under social optimum and monopoly, if the flexible resource is cheap, the relationship between investment and correlation is positive, and if it is costly, the relationship becomes negative; under duopoly, the relationship is positive.

**Keywords:** capacity investment, cloud computing, competition, demand correlation
**JEL Classification:** D4, L8

**2015/35 Computation of Fisher-Gale equilibrium by auction**
Yurii Nesterov, Vladimir Shikhman

We study the Fisher model of a competitive market from the algorithmic perspective. For that, the related convex optimization problem due to Gale and Eisenberg, [8], is used. The latter problem is known to yield a Fisher equilibrium under some structural assumptions on consumers' utilities, e.g. homogeneity of degree 1, homotheticity etc. Our goal is to examine the applicability of the convex optimization framework by departing from these traditional assumptions. We just assume the concavity of consumers' utility functions. For this case we suggest a novel concept of Fisher-Gale equilibrium by introducing consumers' utility prices. The prices of utility transfer the utility of a consumption bundle to a common numéraire. We develop a subgradient-type algorithm from Convex Analysis to compute a Fisher-Gale equilibrium. In order to decentralize prices, we additionally implement the auction design, i.e. consumers settle and update their individual prices and producers sell at the highest offer price. Our price adjustment is based on a tâtonnement procedure, i.e. the prices change proportionally to consumers' individual excess supplies. Historical averages of consumption are shown to clear the market of goods. Our algorithm enjoys a convergence rate. In worst case, the number of price updates needed to achieve the $\varepsilon$-tolerance is proportional to $\frac{1}{\varepsilon^2}$.

**Keywords:** Fisher equilibrium, computation of equilibrium, price adjustment, convex optimization, subgradient methods, decentralization of prices, auction

**2015/36 Tight MIP formulations for bounded up/down times and interval-dependent start-ups**

Maurice Queyranne, Laurence A. Wolsey

Switching machines on and off is an important aspect of unit commitment problems and production planning problems, among others. Here we study tight mixed integer programming formulations for two aspects of such problems: bounded length on- and off-intervals, and interval-dependent start-ups.
For the problem with both these aspects we develop a tight (convex hull) formulation involving additional variables. For the bounded interval problem we present a tight net- work dual formulation based on new integer variables that allows us to simultaneously treat lower and upper bounds on the interval lengths. This in turn leads to more general results, including simpler proofs of known tight formulations for problems with just lower bounds. For the interval-dependent start-up problem we develop a path formulation that allows us to describe the convex hull of solutions in the space of machine-on and interval-dependent start-up variables.

**Keywords:** production sequencing, unit commitment, bounded up/down times, interval- dependent startups, tight MIP formulations, convex hulls.
**JEL Classification:** C44, C61.

**2015/37 Strategic Promotion and Release Decisions for Cultural Goods**

P. Belleflamme, D. Paolini

We study how producers of cultural goods can strategically increase their promotion budgets to secure the most profitable release dates for their goods. In a game-theoretic setting, where two producers choose their budget before simultaneously setting the release date of their good, we prove that two equilibria are possible: releases are either simultaneous (at the demand peak) or staggered (one producer delays). In the latter equilibrium, the first-mover secures its position by investing more in promotion. We test this prediction on a dataset of more than 1500 American movies released in ten countries over 13 years. Our empirical analysis confirms that higher budgets allow movie studios to move release dates closer to demand peaks.

**Keywords:** Non-price competition, Strategic promotion, Strategic timing, Motion pictures.
**JEL Classification:** L13, L82.

**2015/38 Gender Inequality, Technological Progress, and the Demographic Transition**

N.T. Dao, J. Davila

This paper proposes a new mechanism linking technology, the gender gap in education, and fertility in a growth model in order to explain the long run transition from stagnation to modern sustained growth, through the demographic transition, and the accompanying improvements in gender equality in education and income. The mechanism includes three main components. First, increases in the level of technology not only increase the return to human capital but also reduce women's time in doing housework, leaving women with more time for child care and labor-force participation, since technological progress creates labour-saving products for doing housework. Second, the decreases in women's time devoted to housework in the future make households today invest relatively less in education for their sons in order to invest more in education for their daughters because the marginal return to female education is higher than that to male education, therefore, improving the gender

equality in education. Third, the better gender equality in education, in turn, accelerates the technological progress. This positive feedback loop generates a demographic transition accompanied with accelerated economic growth.

**Keywords:** Technological progress, Gender inequality in education, demographic transition, Fertility, Human capital.
**JEL Classification:** L1, J13, J16, O11, O40.

**2015/39 The Transfer Paradox in Welfare Space**
Th. Demuynck, B. De Rock and V. Ginsburgh

The transfer paradox describes a situation in which a transfer of endowments between two agents results in a welfare decrease for the recipient and a welfare increase for the donor. It is known that in a two-agent regular exchange economy with an arbitrary number of goods, the transfer paradox occurs only if the price equilibrium is unstable. In this paper, we show that in the space of welfare weights, the set of stable equilibria and the set of no-transfer paradox equilibria coincide. As a corollary we also obtain that for two agents and an arbitrary number of goods, the index of an equilibrium in price space coincides with its index in welfare space.

**Keywords:** Welfare equilibrium, Exchange economy, Transfer paradox
**JEL Classification:** D51, D60.

**2015/40 On Harsanyi Dividends and Asymmetric Values**
P. Dehez

The concept of dividend of a coalition introduced by Harsanyi in 1959 within the framework of transferable utility games is a flexible and powerful concept that can be used to characterize different solution concepts, including random order values and weighted Shapley values. Many authors have contributed to that question. Here, we offer a synthesis of their work, with a particular attention to restrictions on dividend distributions, starting with the seminal contributions of Vasil'ev (1978), Hammer, Peled and Sorensen (1977) and Derks, Haller and Peters (2000), until the recent paper of van den Brink, van der Laan and Vasil'ev (2014).

**Keywords:** Harsanyi dividends, Weber set, Weighted Shapley values, Core
**JEL Classification:** C71.

**2015/41 Uncapacitated lot-sizing with stock upper bounds, stock fixed costs, stock overloads and backlogging: A tight formulation**
Laurence A. Wolsey

For an $n$-period uncapacitated lot-sizing problem with stock upper bounds, stock fixed costs, stock overload and backlogging, we present a tight extended shortest path formulation of the convex hull of solutions with $O(n^2)$ variables and constraints, also giving an $O(n^2)$ algorithm for the problem. This corrects and extends a formulation in [11] for the problem with just stock upper bounds.

**Keywords:** lot-sizing, stock upper bounds, stock fixed costs, mixed integer programming, convex hull
**Mathematics Subject Classification:** 90C11, 90C27, 90B05, 90B30.

**2015/42 Monopoly price discrimination and privacy : the hidden cost of hiding**
Paul Belleflamme

A monopolist can use a 'tracking' technology that allows it to identify a consumer's willingness to pay with some probability. Consumers can counteract tracking by acquiring a 'hiding' technology. We show in this note that consumers are collectively better off when this hiding technology is not available, even when consumers can acquire it free of charge.

**Keywords:** price discrimination, privacy, monopoly

**JEL-Classification:** D11, D18, L12, L86

**2015/43 Optimal fertility under age-dependent labor productivity**
Pierre Pestieau and Gregory Ponthiere

In the so-called *Rapport Sauvy* (1962), the French demographer Alfred Sauvy argued that Wallonia's fertility rate was socially suboptimal, and recommended a 20 % rise of fertility, on the grounds that a society with too low a fertility leads to a low-productive economy composed of old workers having old ideas. This paper examines how Sauvy's intuition can be incorporated in the seminal Samuelsonian optimal fertility model (Samuelson 1975). For that purpose, we build a 4-period OLG model with physical capital and with two generations of workers (young and old), the skills of the latter being subject to some form of decay. We characterize the optimal fertility rate, and show that this equalizes, at the margin, the sum of the capital dilution effect (Solow effect) and the labor age-composition effect (Sauvy effect) with the intergenerational redistribution effect (Samuelson effect). Finally, we develop a numerical example, and examine how Sauvy's recommendation can be reconcilied with facts.

**Keywords:** optimal fertility, age structure, overlapping generations, social optimum

**JEL-Classification:** E13, E21, J13, J24

**2015/44 Subjective expected utility with state-dependent but action/observation-independent preferences**
Jacques H. Drèze

Under state-dependent preferences, probabilities and units of scale of state-dependent utilities are not separately identified, in standard models: only their products matter to decisions. Separate identfication has been studied under implicit actions (Drèze 1987) or under explicit actions and observations (Karni 2011). This paper complements both approaches and relates them.

**Keywords:** expected utility, state-dependent preferences, subjective probability

**JEL-Classification:** D81

**2015/45** **Higher education value added using multiple outcomes**
Joniada MILLA, Ernesto SAN MARTIN and Sébastien VAN BELLEGEM

We build a multidimensional value added model to analyze jointly the test scores on several outcomes. Using a unique Colombian data set on higher education within a seemingly unrelated regression equations (SURE) framework we estimate schooloutcome specific value added indicators. These are used to measure the relative contribution of the school on a certain outcome, which may serve as an internal accountability measure. Apart from the evident estimation efficiency gains, a joint value added analysis is preferable to the unidimensional one. First, unless modeled in a multidimensional framework, the comparison of value added estimates for different outcomes within a school is not well defined; our model circumvents this issue. Second, even in the case of a separate major field of study analysis there still exists unobserved heterogeneity due to institutional diversity. This makes it more compelling to employ a rich set of outcomes in computing value added indicators. In the end, we aggregate the outcome-specific value added estimates to produce a composite value added index that reflects the combined value added contribution of all the subjects for each school.

**Keywords:** multidimensional value added, multiple outcomes, quality of higher education
**JEL Classificaiton:** I23, A22, C31, C51

**2015/46** **Social Long-Term Care Insurance with two-sided altruism**
Helmuth CREMER, Pierre PESTEIAU and Kerstin ROEDER

This paper studies the design of a social long-term care (LTC) insurance when altruism is two-sided. The laissez-faire solution is not efficient, unless there is perfect altruism. Under full information, the first-best can be decentralized by a linear subsidy on informal aid, a linear tax on bequests when the parent is dependent and state specific lump-sum transfers which provide insurance. We also study a second-best scheme comprising a LTC benefit, a payroll tax on children's earnings and an inheritance tax. This scheme redistributes resources across individuals and between the states of nature and the tax on children's labor enhances informal care to compensate for the children's possible less than full altruism.

**Keywords**: long-term care, social insurance, two-sided altruism
**JEL Classification:** H2, H5

**2015/47** **Stationarity of heterogeneity in production technology using latent class modelling**
Per J. AGRELL and Humberto BREA-SOLÍS.

Latent class modelling (LC) has been advanced as a promising alternative for addressing heterogeneity in frontier analysis models, in particular those where the individual scores are used in regulatory settings. If the production possibility set contains multiple distinct technologies, pooled approaches would result in biased results. We revisit the fundamentals of production theory and formulate a set of criteria for identification of heterogeneity: completeness (the inclusion of all data in the analysis), stationarity (the temporal stability of the identified production technologies), and endogeneity (no ad hoc determination of the cardinality of the classes). We also distinguish between the identification of a sporadic idiosyncratic shock, an outlier observation, and the identification of a time-persistent technology. Using a representative data set for regulation (a panel for Swedish electricity distributors 2000-2006), we test LC modelling for a Cobb-Douglas production function using the defined criteria. The LC results are compared to the pooled stochastic frontier analysis (SFA) model as a benchmark. Outliers are detected using an adjusted DEA super-efficiency procedure. Our results show that about 78% of the distributors are assigned to a single class, the remaining 22% split into two smaller classes that are non-stationary and largely composed of outliers. It is hardly conceivable that a production technology could change over this short horizon, implying that LC should be seen more as an enhanced outlier analysis than as a solid identification method for heterogeneity in the production set. More generally, we argue that the claim for heterogeneity in reference set deserves a more rigorous investigation to control for the multiple effects of sample size bias, specification error and the impact on functional form assumptions.

**Keywords**: Frontier analysis, latent class models, SFA, DEA, outliers, regulation
**JEL Classification:** D72, L51

**2015/48** **Disparités et convergence économiques : Ensemble mais différents.**
Mattéo GODIN and Jean HINDRIKS.

Nous étudions la distribution des revenus et de la production entre régions et entre arrondissements en Belgique pour la période 2000-2013. Le résultat central est l'absence de convergence de la production par habitant entre la Wallonie et la Flandre. En revanche, la production par habitant en Flandre et en Wallonie converge vers la production par habitant de Bruxelles-Capitale du fait de l'expansion démographique de cette dernière. En ce qui concerne le revenu disponible par habitant, il existe une

convergence réelle, mais son rythme reste lent : il faudrait 14 ans pour résorber la moitié des écarts de revenu disponible entre arrondissements d'une même région et 49 ans pour résorber la moitié des écarts entre régions. Les moteurs de cette convergence sont les navettes et la mobilité résidentielle.

**Keywords**: convergence économique, développement régional et pôles de compétitivité

**2015/49** **Modeling poset convex subsets.**
Maurice QUEYRANNE and Laurence A. WOLSEY.

A subset *S* of a poset (partially ordered set) is *convex* if and only if *S* contains every poset element which is between any two elements in *S*. Poset convex subsets arise in applications that involve precedence constraints, such as in project scheduling, production planning, and assembly line balancing. We give a strongly polynomial time algorithm which, given a poset and element weights (of arbitrary sign), finds a convex subset with maximum total weight. This algorithm relies on a reduction to a maximum weight filter (or closure) problem in a poset about twice the size of the given poset; the latter problem is wellsolved as a minimum *s-t* cut problem. We also use this reduction to construct a compact, ideal extended formulation for the convex hull *Cp* of the characteristic vectors of all convex subsets in poset *P*. We define a class of *alternating inequalities* that are valid for *Cp* and admit a linear time separation algorithm based on Dynamic Programming (DP). Furthermore, whenever the point to separate is actually in *Cp* the associated DP value functions induce a feasible solution to the extended formulation. This implies that the alternating inequalities and nonnegative inequalities suffice to describe *Cp*. We conclude by showing that this polyhedral description is minimal, and thus also admits a linear time separation algorithm.

**Keywords**: partial order, convex subsets, extended formulation, convex hull, separation algorithms, dynamic programming
**AMS 2010 Mathematics Subject Classiffication:** 06A06, 90C27, 90C57

**2015/50** **A new index combining the absolute and relative aspects of income poverty: Theory and application.**
Benoît DECERF.

I derive a new index combining the absolute and relative aspects of income poverty. Earning a larger income decreases one's absolute poverty but experiencing a larger income inequality increases one's relative poverty. Provided that the individual poverty is not computed based on the normalized income, the two aspects can be weighed such that absolutely poor individuals are always considered poorer than relatively poor individuals. Only the value of poverty aversion associated with the Poverty Gap Ratio is consistent with this approach. An application illustrates that the new index yields intuitive judgments about unequal growth experiences, for which all absolute (resp. relative) poverty indices systematically conclude that poverty has decreased (resp. increased).

**Keywords**: Income Poverty Measure, Relative Poverty, Absolute Poverty, Income Inequality, Poverty Lines, Decomposable Index